ESTIMATION OF PREY BASE AND ITS IMPLICATIONS IN KUNO WILDLIFE SANCTUARY

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The Asiatic Lion *Panthera leo persica* is restricted to the Gir National Park and Sanctuary in India, which is the only site holding the last surviving wild population of Asiatic Lion in the world. Kuno Wildlife Sanctuary (WLS) in northwest Madhya Pradesh was selected as the site to establish a second home for the Asiatic Lion. Twenty-four villages were rehabilitated outside the Sanctuary to create a large forest habitat free from human disturbance for the Lions. To assess wild prey availability for the Lions in the Sanctuary, distance sampling method was used to collect and analyse data from roads traversed as transects. Cattle population was estimated using direct head counts at yarding sites. The study was carried out in 2004. The estimated combined density of all the major prey excluding Common Langur and cattle in the Sanctuary was 12.11 animals/sq. km. It was found that the total available prey base including feral cattle and wild ungulates was 1993 kg/sq. km, which is still less than the wild prey biomass of 2784.9 kg/sq. km reported from Gir. While this prey base can support a small reintroduced population of 6-10 Lions, it is recommended that efforts to develop a sufficient wild prey base be given the highest management priority.

Key words: Asiatic Lion, extinction, prey base, distance sampling, prey biomass, habitat recovery.

INTRODUCTION

The only free-ranging population of Asiatic Lions *Panthera leo persica* survive in Gir National Park and Sanctuary (Gir forest) of the western Indian state of Gujarat. In the past, their population declined to its lowest number in 1893 when only 18 individuals remained (Saberwal *et al.* 1994; Divyabhanusinh 2005). Following conservation efforts, the species has made a remarkable recovery (Joslin 1973; Berwick 1974; Chellam 1993; Jhala *et al.* 1999; Divyabhanusinh 2005). This isolated, small and single population of Asiatic Lion in Gir faces a variety of extinction threats (Soule 1987) and reintroduction is one of the measures advocated to ensure its long term survival (Sale 1986; IUCN/SSC-RSG).

In 1993, during a workshop on Population and Habitat Viability Analysis at Vadodara (now Baroda), a list of protected areas that could potentially serve as an alternate home for some lions was drafted in consultation with the forest departments of Gujarat, Uttar Pradesh, Madhya Pradesh, Rajasthan and Haryana. After an extensive survey of several potential sites, three locations were short-listed as possible re-introduction sites for this population. These were Darrah and Jawaharsagar Wildlife Sanctuaries (WLS) and Sitamata WLS in Rajasthan, and Kuno WLS in Madhya Pradesh. After an assessment of these sites, Kuno WLS was selected as the most suitable site for translocation of Lions from the Gir forest to establish a second free-ranging population in India (Chellam *et al.* 1995). After its selection as the site for translocation of the Asiatic Lions, one of the first tasks undertaken by the Kuno WLS management was the rehabilitation of the twenty four villages situated within the Sanctuary. This was considered necessary to create a large inviolate core area, which is free from anthropogenic pressures (Khan *et al.* 1996; Chundawat 2001; Biswas and Sankar 2002; Bagchi *et al.* 2003) to ensure survival of the introduced Lion population. Creation of a large core area free from anthropogenic disturbance also provided an ideal opportunity to study the recovery of the habitat and existing prey populations, and establish baseline information for future reference and monitoring of this important and critical habitat.

The information presented in this paper is an attempt to quantitatively assess prey base by estimating its density and biomass that could support the proposed Lion introduction in the Sanctuary.

STUDY AREA

The Kuno WLS is located between 25° 30'- 25° 53' N and 77° 07'-77° 26' E, in the Sheopur district situated in the north-west of the state of Madhya Pradesh. The total area of Kuno WLS is 345 sq. km and an additional 924 sq. km of the surrounding territorial forest is added under the same management programme. The entire area of 1,269 sq. km is now managed as Kuno Wildlife Division with an objective

to establish a second home for the Asiatic Lion. The forests of Kuno WLS represent the Northern Tropical Dry Deciduous Forest (Champion and Seth 1968) and is dominated by *Anogeissus pendula, Anogeissus latifolia, Boswellia serrata* and *Acacia catechu* with extensive Savannah woodlands forming an ideal habitat for the Asiatic Lion. The river Kuno runs through the Sanctuary and is the main source of water. The major prey species for Lion in the Wildlife Sanctuary are Chital *Axis axis*, Chinkara *Gazella bennettii*, Sambar *Cervus unicolor*, Nilgai *Boselaphus tragocamelus*, Wild Pig *Sus scrofa*, Blackbuck *Antelope cervicapra*, Four-horned Antelope *Tetracerus quadricornis* and Common Langur *Semnopithecus entellus*. Leopard *Panthera pardus*, Dhole *Cuon alpinus* and Grey Wolf *Canis lupus* are the main carnivores found in the area, apart from some occasional reports of Tiger *Panthera tigris*.

METHODS

A) Population estimation of wild prey species

Distance sampling (Anderson *et al.* 1979; Burnham *et al.* 1980; Buckland *et al.* 1993) is a widely used reliable (Anderson *et al.* 2001) method for estimating wild animal populations in the tropical forests (Karanth and Sunquist 1992; Varman and Sukumar 1995; Khan *et al.* 1996; Biswas & Sankar 2002; Bagchi *et al.* 2003).

We used both foot and vehicle transects to monitor and estimate herbivore densities in the Kuno WLS. Seventeen line transects were monitored, but data collected was not sufficient to estimate population densities. As a surrogate method, the extensive network of roads in the forest were used as vehicle transects to estimate prey densities. These roads were monitored on a very systematic schedule from an open hooded jeep travelling at speeds less than 20 km/hr by two observers. Vehicle transects allowed larger distances to be covered in shorter time. This facilitated sufficient sightings of animals to employ distance sampling methodology for analysis. In Kuno, animals are more active during early mornings and late evenings, hence higher encounter rate is expected, which maximises efficiency in terms of effort (Karanth *et al.* 2002). Road transects were travelled between 0545 hrs and 0820 hrs, and 1645 hrs and 1910 hrs. Nine road transects were established for monitoring wild prey and the transect lengths varied from 10 to 31 km. Each road transect was traversed several times in the months of April and May 2004. Total length covered in the entire sampling effort was 760 km. For each animal sightings on transects, data about species, group size, age class, sex and perpendicular distance from the road were recorded. Laser rangefinder was used to estimate distance of animal group from the road.

These roads were selected considering maximum coverage of the study area. Since human movement in Kuno Wildlife Sanctuary is minimal, most of the roads are mere clearings with negligible disturbance affecting animals. There was little traffic on the roads and hence we can assume a uniform distribution of animals with respect to the line (roads). However, there were limitations in this case considering the coverage of the study area by the roads and behavioural response by animals where they would have avoided or preferred the roads. Despite the shortcomings, the results can still be used as useful baselines for an area where no prior data is available on the prey base density.

For analyses, detection functions of all species were estimated separately. This was done to incorporate the effect of size and behavioural differences between species in modelling the detection probability. Empirical data were also used to test for evidence of any evasive or invasive movement of animals towards the line of movement, which were the forest roads in this case.

B) Population estimation of feral cattle

Despite successful rehabilitation of 24 villages from within the Sanctuary, a large population of livestock has been left behind. This cattle population has now become feral. This feral livestock population forms a substantial herbivore biomass and is a potential prey for the large carnivore population in the Sanctuary. This population can grow fast and may compete with wild prey population thereby affecting the habitat and wild prey recovery. Therefore, it is important to assess the size of this feral livestock population, and its regular monitoring will be necessary for the management to make crucial decisions. This feral livestock population has formed several large herds and they return to the same yarding sites (night shelter) every night. The research team conducted a detailed survey of each of the identified yarding sites (night shelter) to conduct a head count.

RESULTS

A) Population estimation of wild prey species

During the road survey 507 groups comprising of 2,334 animals were sighted, of which 1,104 could be aged and sexed. These included 823 Chital, 388 Chinkara, 122 Nilgai, 36 Sambar, 17 Four-horned Antelopes and 10 Blackbuck.

The sex ratio was found biased towards the female for Chinkara (100F:54M) and Chital (100F:42M) but this ratio was close to unity in Nilgai (100F:90M) and Sambar (100F:107M) populations (Fig. 1). The female to fawn and female to yearling ratios for all species were very low except in Blackbuck population, but it is based on a very small

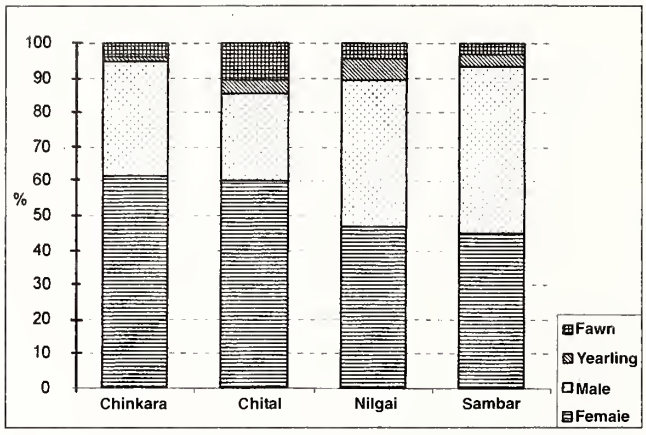

Fig. 1: Demography of main prey species in Kuno Wildlife Sanctuary

population. Female to fawn ratio ranged from a minimum of 100F:6 fawns in Chinkara to 100F:18 fawns in Chital. Similarly, yearling to female ratio was also low, ranging from a minimum of 100F:2 yearlings in Chinkara to a maximum of 100F:13 yearlings in Nilgai.

No evidence of evasive movement away from the line of movement, or aggregation of animals towards the line of movement was obtained for species other than the Chinkara, Wild Pig and Common Langur. While the histogram of Chinkara and Common Langur showed a spike near zero distance, the Wild Pig exhibited slight evasive movement or avoidance of the roads (Figs 2a-2f).

Detailed information on the group densities and group size is given in Table 1. Average group size (Table 1) of all the major prey species observed in Kuno WLS is smaller than other prey populations studied in dry forest (Khan *et al.* 1996; Chundawat 2001; Biswas and Sanker 2002; Bagchi *et al.* 2003). Largest average for group size was recorded for Chital population 4.29 (±3.51), followed by Wild Pig 4.2 (±4.83), Nilgai 2.35 (±1.86), Chinkara 1.88 (±1.18) and Sambar 1.57 (±0.9).

Table 1: Average group size of the major prey species in KWS

Species	Average Group Size	Group density	Group density CV	Standard Deviation	Range Min%	Range Max%
Chinkara	1.88	1.555	14.10	1.18	1	7
Chital	4.29	2.208	13.30	3.51	1	17
Nilgai	2.35	0.339	21	1.86	1	8
Sambar	1.57	0.231	29.70	0.90	1	4
Wild Pig	4.20	0.759	29	4.83	1	21

The density of all the wild prey, excluding Common Langur and feral cattle, in the Sanctuary is 12.11/sq. km (Table 2). The combined density of all wild herbivores, including langur (5.26/sq. km) and feral livestock (5.77/sq. km) estimated by the road transect distance sampling was 23.12 animals/sq. km. Chital is the most abundant wild prey, with a density of 6.61/sq. km followed by Chinkara. Other prey species are found in very low densities (<< 1 animal/ sq. km). Chital was also the most frequently encountered prey species followed by Chinkara, Nilgai, Sambar, Common Langur and Wild Pig. Abundance of Sambar, which is one the major prey animals of Lions in Gir forest, is relatively low in Kuno WLS.

B) Population Estimation of Feral Cattle

Cattle were found to be distributed almost in the entire Sanctuary. Initially a head count of the cattle was carried out in all of the evacuated village sites. In addition to this, cattle were also recorded during the road transect exercise. Head count of the cattle provided an estimate of 1,934 individuals in 16 yarding sites. The largest livestock population was counted in Palpur (680) and Paira (332) villages. This count translates into a density of 5.6 feral cattle/sq. km accounting for 1400 kg of biomass per square kilometre (mean weight 250 kg per cattle).

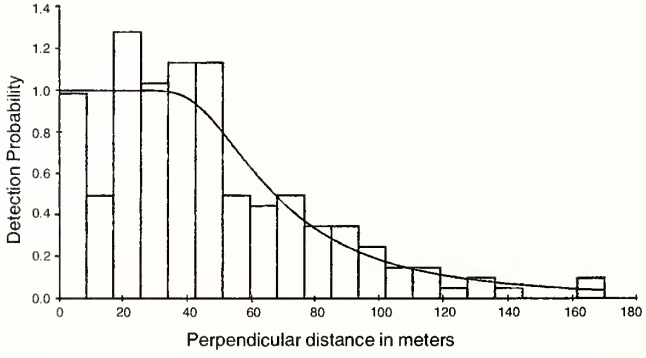

Fig. 2a: Detection Function of Chital Hazard rate model key function ($P_{chi\ square}$ = 0.49)

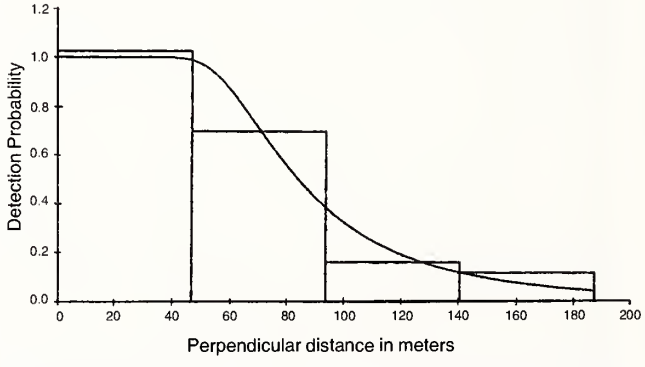

Fig. 2b: Detection Function of Nilgai Hazard rate model key function ($P_{chi\ square}$ = 0.32)

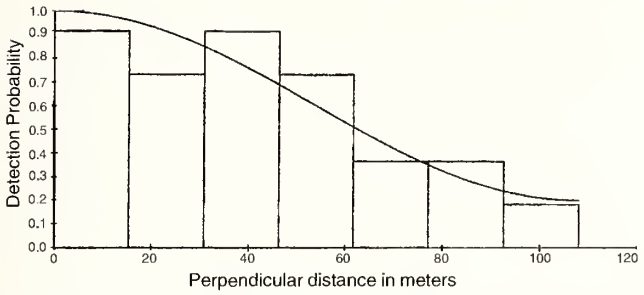

Fig. 2c: Detection Function of Sambar Uniform key function with cosine adjustment ($P_{chi\ square}$ = 0.32)

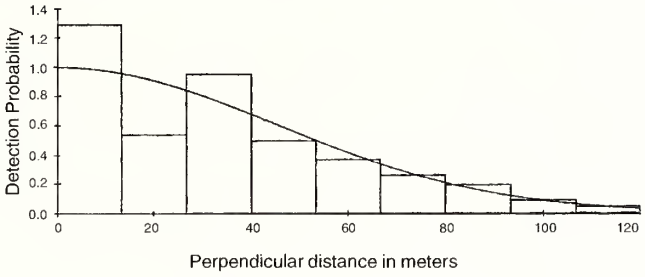

Fig. 2d: Detection Function of Chikara (note the spike in detection probability at zero distance indicating either greater visibility or aggregation of animals in the roads serving as micro habitats). Before truncation: Half normal key ($P_{chi\ square}$ = 0.66)

DISCUSSION

The low ratios of fawn and yearling to female suggests a very low recruitment and could be affecting the fast recovery of wildlife populations in Kuno WLS. These ratios are well below other documented wildlife populations of the dry forest habitat across the country (Khan *et al.* 1996; Chundawat 2001; Biswas and Sanker 2002; Bagchi *et al.* 2003). This needs to be investigated in greater detail and requires intensive monitoring to determine the ratios at birth (or ratios at first two months after fawning in October and November). In addition to this, to facilitate higher recruitment and survival in these age classes, information on mortality rates in different seasons will be critical for the management to take necessary action. Simultaneously, a detailed study to gather information on the ecological factors responsible for such low productivity of the population is essential. Since, transects were monitored at the end of the winter season, it is likely that most of the mortality had occurred by then in these age groups. The prevailing drought conditions could be responsible for most of the mortalities, and this dataset could be reflecting an unusually low female to fawn and yearling ratio. Further monthly monitoring of the prey population shall provide more detailed information and would be helpful in making appropriate management decisions.

We are considering density of groups rather than animals as one of the factors in assessing the possibility of introducing Lions in the area. Density of groups is likely to affect encounter rates of prey species and can thereby influence predators' ecology, predation, ranging, and space use patterns. Group densities of wild prey population in Kuno WLS are considerably lower than other PAs that support viable populations of large carnivores. This could be a crucial ecological factor for successful introduction of Lions in Kuno and therefore require immediate management attention.

Plots of detection probability of each species are useful to investigate various effects of animal response and distribution that may have affected the detection probability and hence density estimates. The spike can be interpreted either as an evidence of preference of roads as micro habitats or a sign of improved visibility. Similarly, evasive movement can be interpreted as the avoidance of roads or effect of disturbance due to the movement of observers. While the evasive movement away from the line of movement could be detected using the plots, it was not too profound to discard the results, and with little adjustments in the model, data was made usable. The density estimates presented here may be slightly biased due to the constraints in the methodology where we used forest roads instead of proper lines.

The density estimate of 12.11Wild ungulates/sq. km is also lower than those reported in other similar dry forest habitats (Khan *et al.* 1996; Chundawat 2001; Biswas and

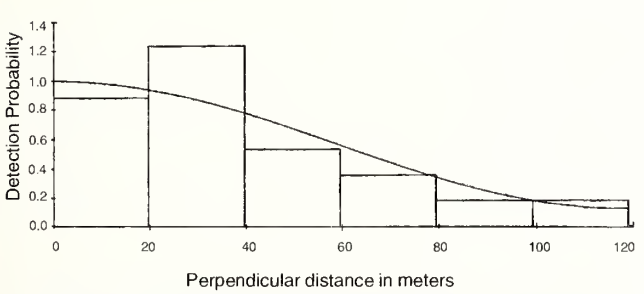

Fig. 2e: Detection Function of Wild Pig Uniform key with cosine adjustment ($P_{chi\ square}$ = 0.84)

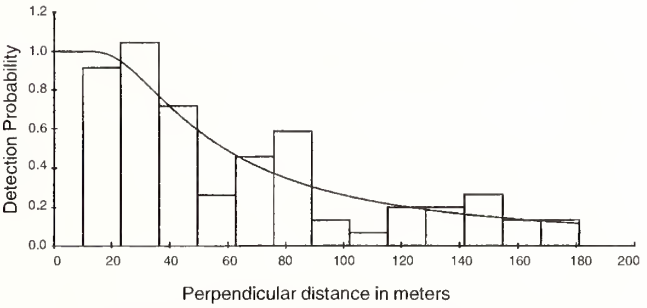

Fig. 2f: Detection Function of Common Langur (left truncation done to adjust spike) Hazard rate key model ($P_{chi\ square}$ = 0.84)

Sanker 2002; Bagchi *et al.* 2003). Among the ungulate prey species found in Kuno WLS, Chital was recorded with the highest density (6.61/ sq. km) and it accounts for over fifty percent of the entire wild prey base available (Table 2). The contribution from other major wild prey species, Sambar and Nilgai in Kuno WLS was small (only 9%). Kuno's large span of open forest habitat and mosaic of open and closed canopy forest are suitable for species like Chital, Nilgai and Chinkara and these species are widely distributed. Large and social herbivores such as Nilgai are partial to more open habitats, and therefore Nilgai and to some extend Chital can prove to be ideal prey for Lions (Chellam 1993). In a dry forest, such as the Kuno WLS, contribution from Nilgai population is substantial to the prey availability (Khan 1996; Chundawat 2001; Biswas and Sanker 2002). It can play a significant role in the ecology of introduced Lions in Kuno WLS, where large expanses of open habitats have been created after the rehabilitation of the villages. Therefore, monitoring of these open habitats in term of its recovery and utilisation by different prey population is essential to assess the suitability of these habitats in managing the introduced Lion population.

Current density estimate of wild prey in Kuno WLS is substantially lower than the reported density of 56.2 ungulates/ sq.km from Gir National Park (Khan 1996). This abundant ungulate prey biomass of Gir forest is able to support a large population of Asiatic Lion (approximately 15.86 adult Lions/ 100 sq. km) and leopards (Khan *et al.* 1996; Jhala *et al.* 1999). The predator to prey ratio estimated in terms of number of prey animals for every Lion in Gir forest is 353 wild prey animals per Lion (excluding cattle and langur). Whereas, with the current ungulate density (i.e. 12.11 animals/sq. km) in Kuno WLS, based on ratio obtained from Gir forest, the number of Lions that Kuno's wild prey base can support is just 11 or 12. Considering the low density of prey causing scattered distribution, each kill will have a higher energy cost attached to it (Gittleman 1996). This may result in increased search activity and hence introduced Lions are likely to roam widely in search of prey. During this search Lions can easily stray out of the core area, which can increase the chances of Lion entering into conflict with neighbouring human habitation on a regular basis.

Estimated abundance and biomass of wild prey alone is certainly not sufficient to support an introduced Lion population. When these density figures are used to estimate the prey biomass, it is observed that the share per Lion in Kuno will be 93 kg/sq. km of wild prey. In Gir forest this share is about 437.87 kg/sq. km, which is about five times higher (Table 3). This indicates that if Lions are introduced now, their survival and establishment will depend largely on how they respond to this limited wild prey availability in Kuno WLS. Straying in search for prey and frequent encounter with human population may not be an ideal situation for an introduction programme of a large cat.

The feral livestock population is an important prey resource for Lions in Gir forest (Joslin 1973; Chellam 1993). When taken into account as a potential prey biomass for the introduced Lion population, livestock biomass in Kuno WLS is around 1990 kg/sq. km (mean weight 250 kg per cattle). This is still far less than reported for wild prey in Gir forest, i.e. 2,784 kg/sq. km (Khan *et al.* 1996) but it is large enough to support a small introduced population of 6-10 Lions in the Kuno WLS. Livestock can at best be considered as supplementary prey. Dependence of Lions mainly on the feral livestock population has always been a debatable subject. With active management, dependence of predators on livestock can be reduced over time, and significant shifts in predator diets have been reported (Kitchener 1991; Chellam 1993) in response to enhanced wild prey availability. During the 16 years between 1973 and 1989, Chellam (1993) reports a

Table 2: Estimated density of wild ungulates, prey of proposed introduce lion population in KWS

Species	Density/ sq. km	Density CV%	95% confidence LCL	95% confidence UCL	Encounter Rate per km
Chital	6.61	15.40	4.882	8.97	0.24
Chinkara	3.62	14.30	2.736	4.803	0.17
Nilgai	0.77	23.60	0.489	1.231	0.06
Sambar	0.30	31.60	0.163	0.557	0.03
Common Langur	5.26	30.20	2.933	9.447	0.02
Wild Pig	0.79	38.90	0.373	1.682	0.1

Table 3: Estimation of prey biomass in Gir and Kuno

Species	Average Wt (in kg)	Gir National Park per sq. km		Kuno Wildlife Sanctuary per sq. km	
		Density	Biomass	Density	Biomass
Chital	47	50.8	2387.6	6.6	311.05
Sambar	134	2.00	268	0.3	40.33
Nilgai	125	0.58	72.5	0.77	97
Four-horned Antelope	21	0.42	8.82	0.02*	0.46*
Chinkara	20	2.4	48	3.6	72.5
Wild Pig	32	0	0	0.79	25.34
Common Langur	9	0	0	5.26	47.37
Total		56.2	2784.9	17.37	593.6

*(Since only 17 Four-horned Antelopes were seen in our study, it was not possible to develop a detection function and hence estimate density reliably)

substantial drop in frequency of livestock remains in scats of Asiatic Lions from 78.5% to 25.9%. Our preliminary results clearly indicate that immediate management attention and intensive monitoring of wild prey and livestock population is urgently required.

Despite the relatively high variance associated with the present estimates, herbivore density in Kuno Wildlife Sanctuary is low when we compare it with other PAs. The reason for this could be the presence of 24 villages within the Sanctuary until recently. Additionally, their livestock and a fairly large migratory cattle population coming from Rajasthan for traditional grazing till the recent past had severely affected the wildlife population and their forest habitat. Despite the strict protection and intensive conservation measures that have been initiated in the last couple of years after voluntary relocation of villages from within the Kuno WLS, it is still too early to expect a spectacular change in the wild herbivore population. But several case studies have been documented where wild herbivore populations have shown significant recoveries after removal of biotic pressures (Panwar 1991; Karanth and Sunquist 1992; Khan *et al.* 1996). In Gir, Chital population increased by 1,320% in 19 years (Khan *et al.* 1996), whereas in Kanha, it was the highly threatened *Cervus duvauceli branderi* which benefited from such management interventions (Gopal 1995).

The management of Kuno WLS has achieved a significant conservation goal by eliminating anthropogenic biotic pressure and creating a habitat suitable for Lion prey such as Chital, Sambar, Nilgai and Wild Pig. It has to be considered that recovery of these wildlife populations will take its time as documented for other PAs (Panwar 1991; Karanth and Sunquist 1992; Khan *et al.* 1996). A large feral livestock population can become a major factor affecting the recovery of the wild prey populations in Kuno WLS, if it continues to grow. For a fast recovery of wildlife population, a systematic management of feral livestock population is essential. This may reduce interspecific competition for forage, especially for Chital and provide them access to their preferred habitats that comprise mainly of ecotones and perennial water sources (Mishra 1982). Feral livestock population can at best be considered as a supplementary prey base, whereas efforts to develop a wild prey base sufficient to support the introduced Lions should be given the highest management priority. These are warranted for achieving the proposed goal of establishing a second home for the Asiatic Lions in Kuno WLS.

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